AIMMS Language Reference - Preface

This file contains only one chapter of the book. For a free download of the complete book in pdf format, please visit www.aimms.com.

Preface

The printed AIMMS documentation consists of three books

- AIMMS—*The User's Guide*,
- AIMMS—*The Language Reference*, and
- AIMMS—*Optimization Modeling*.

Three AIMMS *books*

The first two books emphasize different aspects in the use of the AIMMS system, while the third book is a general introduction to optimization modeling. All books can be used independently.

In addition to the printed versions, these books are also available on-line in the ADOBE Portable Document Format (PDF). Although new printed versions of the documentation will become available with every new functional AIMMS release, small additions to the system and small changes in its functionality in between functional releases are always directly reflected in the online documentation, but not necessarily in the printed material. Therefore, the online versions of the AIMMS books that come with a particular version of the system should be considered as the authoritative documentation describing the functionality regarding that particular AIMMS version.

Available online

Which changes and bug fixes are included in particular AIMMS releases are described in the associated release notes.

Release notes

What is in the AIMMS documentation

The AIMMS User's Guide provides a global overview of how to use the AIMMS system itself. It is aimed at application builders, and explores AIMMS' capabilities to help you create a model-based application in an easy and maintainable manner. The guide describes the various graphical tools that the AIMMS system offers for this task. It is divided into five parts.

The User's Guide

- Part I—*Introduction to* AIMMS—what is AIMMS and how to use it.
- Part II—*Creating and Managing a Model*—how to create a new model in AIMMS or manage an existing model.
- Part III—*Creating an End-User Interface*—how to create an intuitive and interactive end-user interface around a working model formulation.

- Part IV—*Data Management*—how to work with cases and datasets.
- Part V—*Miscellaneous*—various other aspects of AIMMS which may be relevant when creating a model-based end-user application.

The AIMMS Language Reference provides a complete description of the AIMMS modeling language, its underlying data structures and advanced language constructs. It is aimed at model builders only, and provides the ultimate reference to the model constructs that you can use to get the most out of your model formulations. The guide is divided into seven parts.

The Language Reference

- Part I—*Preliminaries*—provides an introduction to, and overview of, the basic language concepts.
- Part II—*Nonprocedural Language Components*—describes AIMMS' basic data types, expressions, and evaluation structures.
- Part III—*Procedural Language Components*—describes AIMMS' capabilities to implement customized algorithms using various execution and flow control statements, as well as internal and external procedures and functions.
- Part IV—*Sparse Execution*—describes the fine details of the sparse execution engine underlying the AIMMS system.
- Part V—*Optimization Modeling Components*—describes the concepts of variables, constraints and mathematical programs required to specify an optimization model.
- Part VI—*Data Communication Components*—how to import and export data from various data sources, and create customized reports.
- Part VII—*Advanced Language Components*—describes various advanced language features, such as the use of units, modeling of time and communicating with the end-user.

The book on optimization modeling provides not only an introduction to modeling but also a suite of worked examples. It is aimed at users who are new to modeling and those who have limited modeling experience. Both basic concepts and more advanced modeling techniques are discussed. The book is divided into five parts:

Optimization Modeling

- Part I—*Introduction to Optimization Modeling*—covers what models are, where they come from, and how they are used.
- Part II—*General Optimization Modeling Tricks*—includes mathematical concepts and general modeling techniques.
- Part III—*Basic Optimization Modeling Applications*—builds on an understanding of general modeling principles and provides introductory application-specific examples of models and the modeling process.
- Part IV—*Intermediate Optimization Modeling Applications*—is similar to part III, but with examples that require more effort and analysis to construct the corresponding models.

■ Part V—*Advanced Optimization Modeling Applications*—provides applications where mathematical concepts are required for the formulation and solution of the underlying models.

In addition to the three major AIMMS books, there are several separate documents describing various deployment features of the AIMMS software. They are:

■ AIMMS—*The Function Reference*,
■ AIMMS—*The COM Object User's Guide and Reference*,
■ AIMMS—*The Excel Add-In User's Guide*, and
■ AIMMS—*The Open Solver Interface User's Guide and Reference*.

These documents are only available in PDF format.

Documentation of deployment features

The AIMMS documentation is complemented with a number of help files that discuss the finer details of particular aspects of the AIMMS system. Help files are available to describe:

Help files

■ the execution and solver options which you can set to globally influence the behavior of the AIMMS' execution engine,
■ the finer details of working with the graphical modeling tools, and
■ a complete description of the properties of end-user screens and the graphical data objects which you can use to influence the behavior and appearance of an end-user interface built around your model.

The AIMMS help files are both available as Windows help files, as well as in PDF format.

Two tutorials on AIMMS in PDF format provide you with some initial working knowledge of the system and its language. One tutorial is intended for beginning users, while the other is aimed at professional users of AIMMS.

AIMMS *tutorials*

As the entire AIMMS documentation is available in PDF format, you can use the search functionality of Acrobat Reader to search through all AIMMS documentation for the information you are looking for.

Searching the documentation

AIMMS comes with an extensive model library, which contains a variety of examples to illustrate simple and advanced applications containing particular aspects of both the language and the graphical user interface. You can find the AIMMS model library in the Examples directory in the AIMMS installation directory. The Examples directory also contains an AIMMS project providing an index to all examples, which you can use to search for examples that illustrate specific aspects of AIMMS.

AIMMS *model library*

What is in the Language Reference

Part I of the Language Reference introduces and illustrates the basic concepts of the AIMMS language.

Preliminaries

- Chapter 1—*Introduction to the* AIMMS *language*—provides you with a quick overview of AIMMS' modeling capabilities through a simple, and completely worked out example model.
- Chapter 2—*Language preliminaries*—globally describes the basic structure of an AIMMS model, the available data types and execution statements.

Part II introduces the fundamental concepts of sets and multidimensional parameters, and discusses the expressions and evaluation mechanisms available for these data types.

Nonprocedural language components

- Chapter 3—*Set declaration*—discusses the declaration and attributes of index sets.
- Chapter 4—*Parameter declaration*—describes the declaration and available attributes of scalar and multidimensional parameters which can be used to store and manipulate data.
- Chapter 5—*Set, set element and string expressions*—provides a complete overview of all expressions which evaluate to either a set, a set element or a string.
- Chapter 6—*Numerical and logical expressions*—describes all expressions which evaluate to a numerical or logical value, and also explains the concept of macro expansion in AIMMS.
- Chapter 7—*Execution of nonprocedural components*—describes the dependency and automatic execution structure of the system of functional relationships formed by all defined sets and parameters.

Part III focuses on the procedural aspects of the AIMMS language which allow you to implement you own algorithms, seamlessly making use of the advanced built-in functionality already provided by AIMMS.

Procedural language components

- Chapter 8—*Execution statements*—provides a complete overview of all assignment and flow control statements in AIMMS.
- Chapter 9—*Index binding*—specifies the precise rules for the fundamental concept of index binding underlying AIMMS execution engine.
- Chapter 10—*Internal procedures and functions*—explains how to declare and call internal AIMMS procedures and functions.
- Chapter 11—*External procedures and functions*—explains how functions and procedures in an external DLL can be linked to and called from within an existing AIMMS application.

Part IV of the reference guide tries to make you aware of the differences between a dense versus a sparse execution engine (as used by AIMMS). It provides valuable insight into the inner workings of AIMMS and may help to implement large-scale modeling applications in a correct and efficient manner.

Sparse execution

- Chapter 12—*The* AIMMS *sparse execution engine*—provides you with a basic insight into the inner workings AIMMS sparse execution engine, and provides a number of convenience operators to modify the semantics of some operators.
- Chapter 13—*Execution efficiency cookbook*—discusses various techniques that you may apply to find and address performance issues in your AIMMS models.

Part V of the reference guide discusses all concepts offered by AIMMS for specifying and solving optimization models.

Optimization modeling components

- Chapter 14—*Variable and constraint declaration*—discusses the declaration and attributes of variables and constraints.
- Chapter 15—*Solving mathematical programs*—describes the steps necessary for specifying and solving an optimization program in AIMMS.
- Chapter 24—*Node and arc declaration*—discusses the declaration and attributes of node and arc types available in AIMMS to specify single commodity network flow models.
- Chapter 17—*Advanced methods for nonlinear programs*—discusses the multistart algorithm and nonlinear presolver available in AIMMS for nonlinear models.
- Chapter 23—*Mixed complementarity problems*—describes the declaration and attributes of complementarity variables, which can be used to specify mixed complementarity and MPCC models in AIMMS.
- Chapter 19—*Stochastic programming*—discusses the facilities in AIMMS to generate stochastic models and associated scenario trees for existing deterministic model formulations.
- Chapter 20—*Robust optimization*—introduces the facilities in AIMMS to generate and solve robust optimization models for existing deterministic model formulations.
- Chapter 16—*Implementing advanced algorithms for mathematical programs*—describes a library of procedures which allow you to implement advanced algorithms for solving linear and mixed-integer linear programming models.
- Chapter 18—AIMMS *Outer Approximation Algorithm for MINLP*—introduces an open approach to solving MINLP models using the well-known outer approximation algorithm.

Part VI introduces the mechanisms provided by AIMMS to import data from files and databases, as well as its capabilities to export data and produce standardized or customized text reports.

- Chapter 25—*Data initialization, verification and control*—describes your options to initialize the identifiers associated with an AIMMS model. It also introduces the concept of assertions which can be used to verify the consistency of data, as well as a number of data control statements which can help you to keep the data in a consistent state.
- Chapter 26—*The READ and WRITE statements*—describes the basic mechanism offered by AIMMS for data transfer with various data sources.
- Chapter 27—*Communicating with databases*—discusses the specific aspects of setting up a link between AIMMS and a database.
- Chapter 28—*Format of text data files*—presents the various data formats offered by AIMMS for initializing a model through a number of text data files.
- Chapter 29—*Reading and Writing Spreadsheet Data*—provides you with an overview of AIMMS' capabilities to exchange data with Excel or with OpenOffice Calc workbooks.
- Chapter 30—*Reading and Writing XML Data*—discusses AIMMS' facilities to read and write XML data from within AIMMS.
- Chapter 31—*Text reports and listing*—describes the statements and formatting options available for producing standardized and customized text reports.

Part VII of the reference guide introduces a number of advanced features available in AIMMS both in the area of modeling and communication with external applications.

- Chapter 32—*Units of measurement*—discusses the declaration and use of units and unit conventions in an AIMMS model both for checking the consistency of a model formulation, scaling of mathematical programs and display of data in the interface and reports.
- Chapter 33—*Time-based modeling*—describes the advanced concepts in AIMMS to deal with time-dependent data and models in a flexible and easy manner.
- Chapter 34—*The AIMMS programming interface*—offers a complete description of the application programming interface (API) which can be used to access AIMMS data structures and call AIMMS procedures from within an external DLL or application.
- Chapter 35—*Model structure and modules*—discusses the organizational data structures such as the main model, model sections and modules, which can be used to supply the model with a logical structure, as well as library modules, which facilitate model development by multiple developers.

The authors

Marcel Roelofs received his Ph.D. in Applied Mathematics from the Technical University of Twente in 1993 on the application of Computer Algebra in Mathematical Physics. From 1993 to 1995 he worked as a post-doc at the Centre for Mathematics and Computer Science (CWI) in Amsterdam in the area of Computer Algebra, and had a part-time position at the Research Institute for the Application of Computer Algebra. In 1995 he accepted his current position as CTO of AIMMS B.V. His main responsibilities are the design and documentation of the AIMMS language and user interface.

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Johannes Bisschop received his Ph.D. in Mathematical Sciences from the Johns Hopkins University in Baltimore USA in 1974. From 1975 to 1980 he worked as a Researcher in the Development Research Center of the World Bank in Washington DC, USA. In 1980 he returned to The Netherlands and accepted a position as a Research Mathematician at Shell Research in Amsterdam. After some years he also accepted a second part-time position as a full professor in the Applied Mathematics Department at the Technical University of Twente. From 1989 to 2003 he combined his part-time position at the University with managing Paragon Decision Technology B.V. and the continuing development of AIMMS. From 2003 to 2005 he held the position of president of Paragon Decision Technology B.V. His main interests are in the areas of computational optimization and modeling.

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In addition to the main authors, various current and former employees of AIMMS B.V. (formerly known as Paragon Decision Technology B.V.) and external consultants have made a contribution to the AIMMS documentation. They are (in alphabetical order):

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